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Alberta
Energy Resourc
Conservation
Board

PREFACE

"Conservation in Alberta, 1969" has been prepared by the Oil and Gas Conservation Board to acquaint members of the Legislative Assembly of Alberta and the public at large with the conservation of Alberta's oil and gas resources and with the role of the Board. The text has been written in a non-technical style without detailed statistics.

Included in the report are a perspective on the oil and gas industry's pollution control problems, an outline of the responsibilities of the Board, and a brief review of the reserves and production of oil and gas and their by-products. The enhanced recovery of crude oil and the conservation of solution gas are also discussed. This edition includes two special sections, the first dealing with the current practices of the Board in its pollution abatement program, and the second describing the Province's oil productive capacity which was tested to its limit for a brief period last winter. The final section in the report briefly summarizes Board operations during 1969.

The more detailed publication "Report of the Operations of the Oil and Gas Conservation Board" will also be published for general distribution this year.

TABLE OF CONTENTS

Conservation and Pollution 5

Responsibilities of the Board 7

Production and Reserves 8

Enhanced Recovery of Crude Oil 11

Conservation of Solution Gas 13

Pollution Control in Oil and Gas Fields 14

Alberta's Oil Productive Capacity 17

Summary of Board Operations — 1969 21

COVER PICTURE: Our cover picture is a photograph of a modern drilling rig in a foothills setting. It is reproduced courtesy of E. R. Brushett of the Board's staff.

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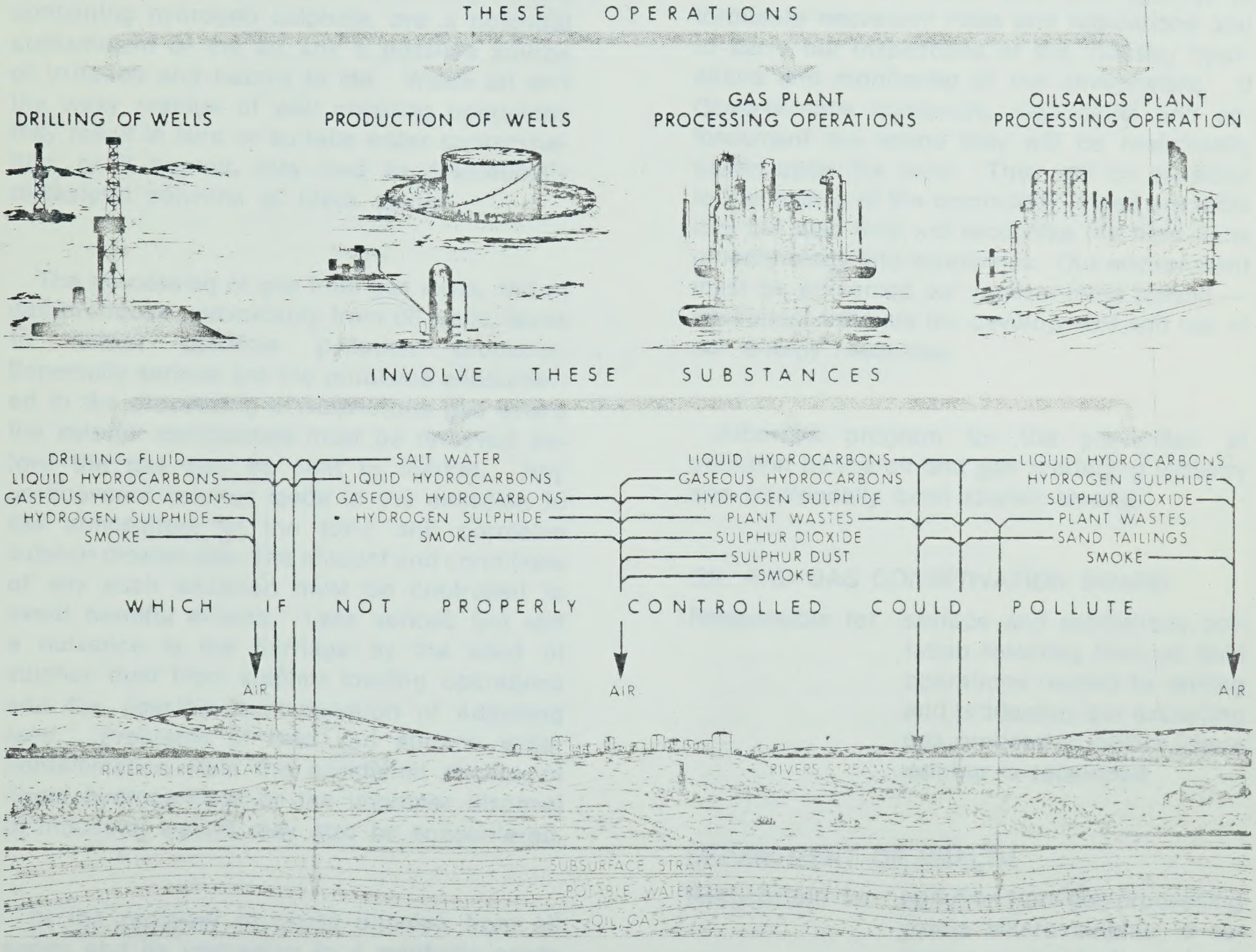
CONSERVATION AND POLLUTION

The last two or three years have seen a great increase in public concern over pollution of all kinds and from all sources. This is good and we must all accept greater responsibility for the preservation of our environment. It is unfortunate, however, that this justifiable concern over a serious problem has led to so many emotion-charged generalizations. We need the facts — the scientific, technological, ecological and economic facts — and we need to analyze them rationally. It seems appropriate in this issue of Conservation in Alberta to discuss possible sources of pollution in the oil and gas producing industry and the preventative measures taken by the industry, the Government, and the Board. This is not the place for a full presentation and analysis of all the facts and details but at least a fair perspective may be given.

In the complex oil and gas producing industry there are many substances from many different operations, which, if great care is not taken, could cause pollution. The accompanying diagram illustrates the situation.

In the drilling of wells, even under normal conditions, drilling mud could escape to cause



POLLUTION PREVENTION AREAS IN OIL AND GAS PRODUCTION OPERATIONS

contamination of land surface or streams, rivers and lakes. If there should be a loss of control during drilling, liquid or gaseous hydrocarbons, or sulphurous gases could escape to cause contamination of land and surface water and the atmosphere. In producing operations, salt water and hydrocarbon vapors (often containing the noxious hydrogen sulphide) are unavoidably produced with crude oil. If not properly disposed of the salt water could destroy the fertility and beauty of the land or contaminate our streams, rivers and lakes. Even if the produced salt water is re-injected underground, as is normal, care must be taken to avoid possible pollution of underground strata containing potable water or potentially recoverable oil or gas. The hydrocarbon vapors, and especially those containing hydrogen sulphide, are a potential contaminant of the air and a possible source of irritation and hazard to life. Waste oil and the waxy residue of well cleaning operations may result in land or surface water contamination, or if burned, may lead to aesthetically distasteful columns of black smoke.

The processing of gas from gas wells, and of gas produced unavoidably from oil wells, leads to further possible pollution problems. Especially serious are the problems encountered in the processing of sulphurous gas where the sulphur compounds must be removed before the gas can be sent to market. Any unrecovered sulphur leads to the emission to the atmosphere of the toxic and corrosive sulphur dioxide gas. The amount and conditions of any such emission must be controlled to avoid harmful effects. Less serious but still a nuisance is the carriage by the wind of sulphur dust from sulphur loading operations and the possible contamination of adjoining land. Problems of land and surface water contamination from the accidental escape of liquid hydrocarbons or the improper disposal of industrial wastes may also be encountered.

In the recovery of crude bitumen from oil sands and its upgrading to a synthetic crude oil pollution hazards similar to those in plants processing sour gas are encountered and some additional ones as well. Plant waste water carries small quantities of unrecovered bitumen and process chemicals. This must be carefully treated before disposal to avoid river contamination. The vast amount of sand tailings from the operation require careful disposal by methods which will ensure safety and stability as well as preventing contamination of the land or surface waters.

The responsibility for the control of pollution to standards acceptable to the community clearly lies with the individuals, companies and industry which acquire the rights to explore and drill for, produce, process and transport our oil and gas resources. Government's role (or that of its agencies) is to establish proper standards of air, water and land quality, to formulate necessary rules and regulations and to carry out inspections of the industry operations and monitoring of the environment. If Government's standards, regulations and enforcement are sound they will be realistically based upon the facts. They will be sensitive to the wishes of the community (these are facts too) but also they will recognize the hard facts of technology and economics. Our environment must be preserved but realism must prevail — we cannot frustrate the development and use of our energy resources.

Alberta's program for the prevention of pollution by the oil and gas producing industry has traditionally been shared among:

OIL AND GAS CONSERVATION BOARD

Responsible for	surface and subsurface pollution resulting from all field operations related to drilling and producing, but excluding gas processing plants where sulphur is recovered

DEPARTMENT OF HEALTH

Responsible for	pollution from gas processing plants where sulphur is recovered; developing standards for air and water quality which are applicable to oil industry

SURFACE RECLAMATION COUNCIL

Responsible for conditioning, maintenance or reclamation of the surface of the land in surveyed areas excepting in forest reserves

DEPARTMENT OF LANDS & FORESTS

Responsible for conditioning, maintenance or reclamation of the surface of the land in unsurveyed lands and in forest reserves

PIPE LINE DIVISION OF
DEPARTMENT OF MINES AND MINERALS

Responsible for approval and testing of pipe lines including pipe line heaters off well and battery sites; clean up of oil spills resulting from pipe line breaks

DEPARTMENT OF AGRICULTURE

Responsible for administration of surface and ground water resources

In an amendment to The Oil and Gas Conservation Act, 1969 at the 1970 session of the Legislature the Board has been asked to assume broader responsibilities in the whole area of pollution control related to the oil and gas producing industry and in particular will become responsible for the regulation of pollution from gas processing and oil sands recovery plants.

In a following section is a brief discussion of some of the measures which the Board has developed over the years for the prevention or abatement of pollution. These measures and the co-ordination of the roles of the Board and other Government Departments for pollution control in the oil and gas industry are now under critical review. The Board believes the record of the Alberta oil and gas industry has been generally good with respect to the potentially most serious matters. There is, however, room for improvement through upgrading of existing standards, tighter controls, and recognition that aesthetic as well as health and safety matters are proper areas of concern. This is a job that the industry and the Board are now tackling.

(From Conservation in Alberta 1969)

RESPONSIBILITIES OF THE BOARD

The Oil and Gas Conservation Board was established by the Alberta Legislature in 1938. In administering the provisions of The Oil and Gas Conservation Act, 1969, its objectives are the conservation of the Province's resources in oil, gas and the oil sands and the prevention of their waste, the ensuring of safe and efficient field practices, the affording of an opportunity for each owner of oil and gas in a pool to recover his share in its production and the recording and dissemination of information regarding the Province's resources in oil, gas and oil sands.

To discharge its responsibilities effectively, the Board must see that in the light of sound engineering and economic principles, oil and gas field operations are so conducted that wells are properly located, spaced, drilled, equipped and produced, so that the recovery of oil or gas from the pool is not lessened and reservoir energy is not improperly dissipated. The Board must also make certain that enhanced recovery techniques are used where suitable and that waste of gas is minimized.

In carrying out these functions the Board, in co-operation with industry, has established specific regulations and policies. The act provides the Board with authority to require operators to undertake operations necessary to improve conservation. The Board, through its staff, maintains a close surveillance of each producing oil and gas field to ensure that producing operations will provide optimum recovery.

The Board has similar duties under the Act with regard to oil sands. It is also guided

in this area by the Government policy of providing for the orderly development of the oil sands in a manner that will supplement but not displace production from the conventional oil industry.

Protection of the interests of owners in oil and gas pools is provided under the Act and Regulations. This is achieved largely by well spacing regulations and by the regulation of production under uniform rules. In exceptional cases further measures, such as common carrier or common purchaser orders, are available.

The Board co-operates with other Government departments and industry to ensure that oil field producing practices do not lead to excessive pollution or the destruction or contamination of other natural resources.

The Board is also responsible under The Gas Resources Preservation Act, 1956, for seeing to the effective utilization of the Province's gas resources. Applications for removal of gas or propane from Alberta are evaluated having regard to the present and future needs of the people within the Province, and permits are granted only for quantities surplus to these needs.

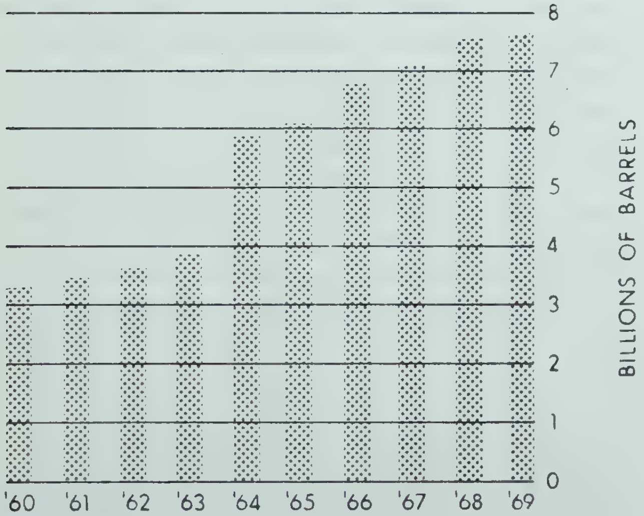
Since 1958, some special responsibilities in the old Turner Valley Field have been given to the Board by The Turner Valley Unit Operations Act. Because of the wide diversity of ownership in the Field, and to expedite plans for improving recovery from it, the Board was authorized to combine diverse holdings into a single unit operation if one or more owners requested it. Five units comprising the whole of the Turner Valley Rundle Pool have since been established.

PRODUCTION AND RESERVES

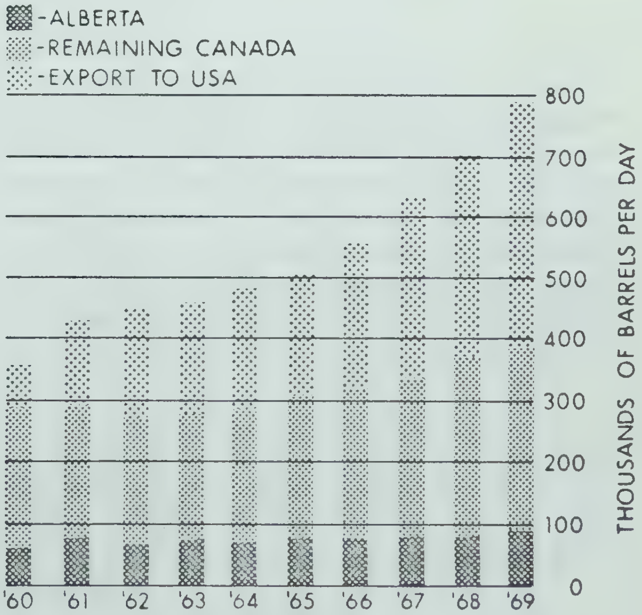
CRUDE OIL

The total of the recoverable reserves of conventional crude oil discovered to date in Alberta rose to 10,683 million barrels at the end of 1969, an increase of 343 million barrels over the 1968 figure. This is the lowest level of growth since 1962. Considered against production of 280 million barrels, the net effect of 1969 reserve growth was to increase the remaining

ALBERTA REMAINING CRUDE OIL RESERVES



ALBERTA CRUDE OIL DELIVERIES



discovered recoverable reserves of Alberta conventional crude oil by 63 million barrels to 7,695 million barrels as of December 31, 1969.

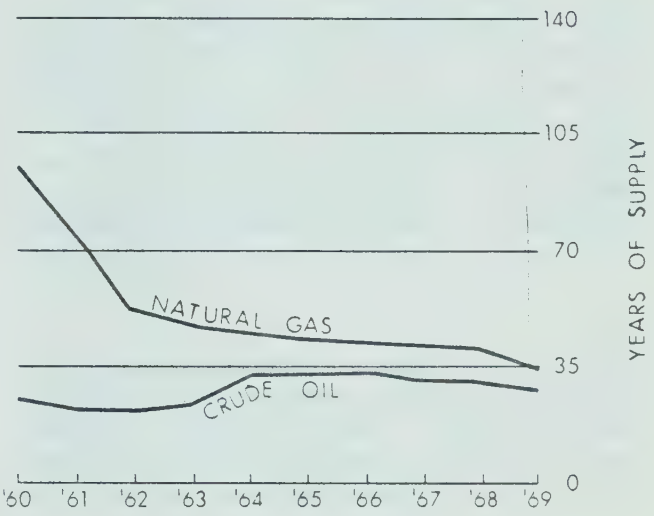
Among pools discovered prior to 1969, there were modest improvements made in methods of recovery. However, these improvements were partially offset by downward adjustments to the Board's previous reserve estimates for some pools. Thus, in total, the reserves of pools discovered prior to 1969 appreciated by only some 90 million barrels during 1969. The major portion of the 1969 increase in initial recoverable reserves of conventional crude oil was attributable to the discovery of new pools, principally in the Rainbow and Zama Lake areas. The reserves credited to all pools discovered during 1969 amounted to some 255 million barrels.

Daily production of Alberta crude oil averaged 793,000 barrels in 1969, up some 13 per cent from the 1968 level of 701,000 barrels per day. Conventional crude oil production averaged 765,000 barrels per day, an increase of 80,000 barrels per day over 1968, while daily production of synthetic crude oil from the Great Canadian Oil Sands Limited plant near Fort McMurray averaged 28,000 barrels, an increase of 12,000 barrels per day over the 1968 production level.

Most of the 1969 increase in Alberta crude oil production resulted from significantly higher demand levels in the United States. Deliveries to United States markets averaged 410,000 barrels per day and were 85,000 barrels per day higher than in 1968, an increase of some 26 per cent. By contrast, Canadian demand for Alberta crude oil increased by only 7,000 barrels per day over 1968 levels and averaged 383,000 barrels per day. 1969 was the first year in which the volume of export of Alberta crude oil to the United States exceeded that marketed within Canada.

Remaining recoverable reserves of Alberta conventional crude oil at year-end 1969 were equivalent to approximately 28 years of supply at 1969 production levels. This index of supply for Alberta conventional crude oil has declined in each of the last three years indicating that, while remaining recoverable reserves continue to increase, they are doing so at a slower rate than markets are expanding. At the end of 1969, Canada as a whole was estimated to have some 22 years of supply of crude oil at 1969 production rates. The historical trend in the index of supply of crude oil and of natural gas is presented in the accompanying figure.

YEARS OF SUPPLY OF ALBERTA
CRUDE OIL AND NATURAL GAS



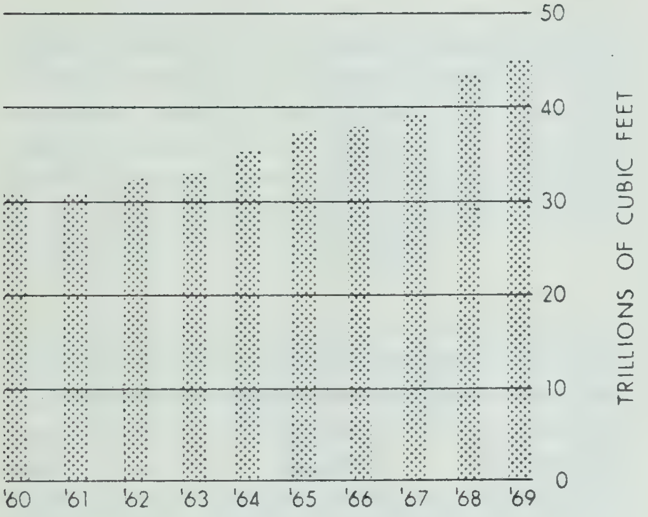
GAS

Alberta's reserves of marketable gas found to date were estimated to be 54.9 trillion cubic feet at year-end 1969, an increase of some six per cent, or 3.1 trillion cubic feet, over the 1968 level. Marketed production of gas increased to 1.3 trillion cubic feet in 1969. Consequently, the remaining marketable reserves at December 31, 1969 expanded marginally to 45.2 trillion cubic feet.

New discoveries at Strachan and Ricinus in the west-central area of the Province and further growth in the Kaybob South Field contributed substantially to the growth of initial reserves.

Deliveries of Alberta gas averaged 3.6 billion cubic feet per day in 1969, an increase of some 20 per cent, or 0.6 billion cubic feet per day, over the corresponding 1968 figure. Production marketed in Canada averaged 2.1 billion cubic feet per day, up from 1.7 billion cubic feet in 1968. Exports to the United States showed continued expansion, averaging 1.5 billion cubic feet per day, an increase of some 12 per cent over the 1968 level.

ALBERTA REMAINING NATURAL GAS RESERVES



On the basis of 1969 remaining marketable reserves and production levels, Alberta had some 35 years of gas supply, as compared to 40 years of supply at the end of 1968. A downward trend in the number of years of supply for gas has been evident over the past decade, with the decline in 1969 being the largest in several years.

NATURAL GAS LIQUIDS

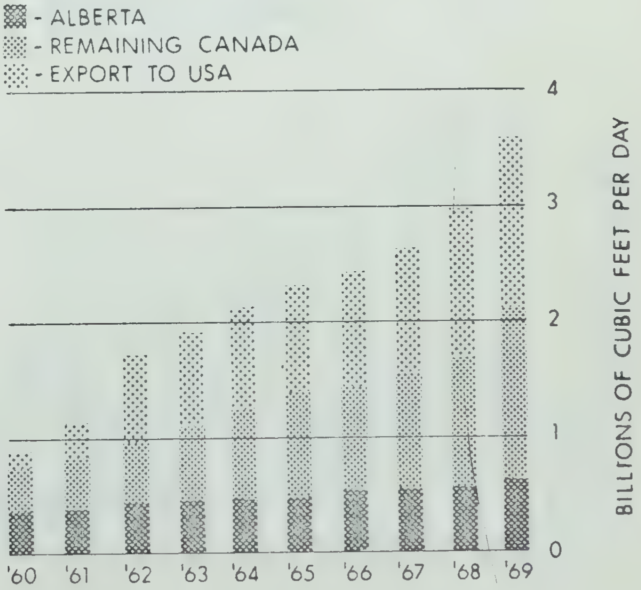
The term natural gas liquids refers to three products — pentanes plus, propane and butane — which are produced in association with conventional crude oil and gas. In 1969, production of these products surpassed 1968 levels, continuing a trend established over the previous ten years.

Pentanes plus is a product with properties similar to those of light crude oil. The two products are marketed in essentially the same areas. In 1969 pentanes plus production increased to 102,000 barrels per day and represented the equivalent of some 13 per cent of the market demand for crude oil, up fractionally from the 1968 figure of 12 per cent. Board estimates placed 1969 remaining recoverable reserves of pentanes plus at 1,048 million barrels, indicating some 28 years of supply at the 1969 rate of production.

Propane production averaged 46,000 barrels per day in 1969, up some 6,000 barrels per day from the 1968 production level. Shipments to United States markets were slightly higher than in 1968, averaging 11,277 barrels daily, while exports to Japan averaged 8,572 barrels daily, an increase of 2,849 barrels per day over 1968. Remaining reserves of propane were estimated at 702 million barrels at year-end 1969.

Alberta production of butane increased to 29,000 barrels per day in 1969 from a daily average of 26,000 barrels in 1968. Demand in both Canada and the United States increased significantly over 1968 levels.

ALBERTA NATURAL GAS DELIVERIES



SULPHUR

All of Alberta's sulphur production is a by-product of the processing of sour gas. While in 1969 the sales of Alberta sulphur rose to 2.6 million long tons from 2.2 million long tons in 1968, the sales volumes represented a smaller fraction of total production than in 1968, and inventories increased significantly. Furthermore, the market price outlook seriously deteriorated during the year with the average monthly sales price declining from about $34.00 per long ton in January to some $13.00 per long ton in December.

Production of sulphur in Alberta was some 3.7 million long tons in 1969, up 22 per cent from that of the previous year. Deliveries to Canadian markets were down slightly from 1968 while shipments to foreign markets showed strong growth, reaching 2.1 million long tons, up some 26 per cent from the 1968 level.

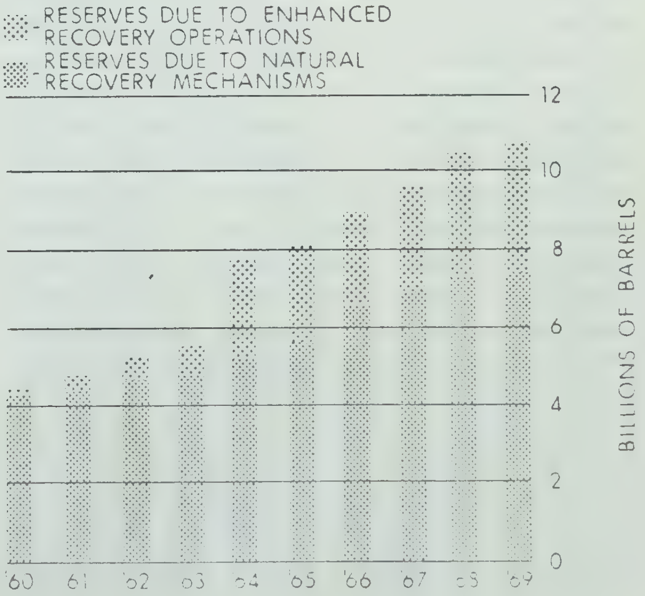
ENHANCED RECOVERY OF CRUDE OIL

Enhanced recovery of crude oil is accomplished by augmenting the natural energy sources available in a given reservoir. This is usually done by the injection to the oil producing zone of either water or gas, and the degree of improvement in oil recovery depends on the viscosity of the oil and the flow channel properties of the reservoir rock.

The Board encourages and may require the use of enhanced recovery techniques wherever the economics of doing so are favorable and, once a plan for enhanced recovery of oil has been put into operation, it periodically reviews the project's performance for recovery efficiency and continued technical suitability.

One of the most significant enhanced recovery schemes initiated during 1969 was that in the Wizard Lake D-3 A Pool. This large pool in central Alberta contained 380 million barrels of oil in place at the time of discovery. It is presently subject to an extensive natural water drive which will result in recovery of approximately 64 per cent of the initial oil in place. To the end of 1969 approximately one quarter of the pool had been swept by encroaching bottom water leaving a remaining oil zone of about 300 million barrels. On the basis of studies it had performed over the past two years, the pool owner decided that the relatively efficient natural recovery mechanism could be even further improved by installing a system to displace the oil with a suitable solvent. In accordance with a scheme approved by the Board, a fluid bank made up chiefly of methane, propane and butane (and referred to as a solvent bank) will be injected near the top of the pool so as to miscibly displace oil from the porous rock as oil is produced from the pool and the bank moves downward. This solvent bank will be injected continuously over a period of 14 years at which time it will be approximately 26 million barrels in size and will be spread out over 1300 acres covering the entire crestal portion of the oil pool. Since the solvent is miscible with the oil, it is capable of displacing nearly 100 per cent of the oil from the pore systems contacted as opposed to the existing water displacement process which results in only about 70 per cent of the oil being displaced.

ALBERTA INITIAL CRUDE OIL RESERVES



Because the propane and butane components of the solvent bank are costly, the total bank must be of limited size if application of the miscible displacement process is to be economically feasible. Once a bank of sufficient size and thickness has been placed, it moves downward followed by a dry displacing gas injected at the top of the pool. In moving downward through the oil saturated rock, the solvent displaces virtually all of the oil ahead of it. It is necessary that at reservoir conditions the solvent bank be fully miscible with both the crude oil in front of it, and the dry gas following, in order for the process to be successful. Therefore, studies were made to determine the range of mixtures which might be used in the solvent bank while retaining miscibility. Based on information from laboratory studies and engineering calculations a solvent bank of optimum size and mixture was chosen. It is expected that additional recovery generated in Wizard Lake will be about 70 million barrels, a significant addition to the Province's crude oil reserves.

In total, 43 new schemes for enhanced recovery located in such wide spread areas as Coutts on the Alberta-Montana border to Zama in the far North-west corner of the Province, were approved by the Board in 1969. Over 90 per cent of the schemes involve some form of water flooding and the aggregate gain in recovery is expected to approach 200 million barrels. Somewhat novel among the new schemes was that implemented in the Pembina Belly River B Pool. The rock matrix in this pool contains a good deal of clay material which, when exposed to fresh water, will undergo significant swelling, thereby plugging off flow channels. A scheme of pattern water flooding has been designed in which the initial water injected will contain calcium chloride at a sufficient concentration to prevent swelling of the clay particles. After injection of about 100,000 barrels of water containing calcium chloride at each injection well, the system will be converted to that of a simple fresh water injection system. It is predicted that ultimate recovery will be increased by 13 million barrels of crude oil, more than double that which would have been recovered under the natural recovery mechanism.

Determination of the basic properties of oil pools in the Rainbow and Zama areas continued to receive considerable attention during 1969. About 400 separate reef pools have now been discovered in these areas, with the reefs varying from simple pinnacles to complex mushroom-shaped configurations. Reasonable definition of the form and extent of each reef is required in order to estimate the oil and gas in place and, also, to predict the efficiency of primary and potential enhanced recovery processes that each pool may undergo. Since most of the pools have only one or two wells, very limited information respecting the shape and geological nature of the reservoir is available in any one case. However, because a large number of wells have been drilled into various points of a large number of pools, it is becoming possible, through the use of geological concepts, to develop a composite model of a typical reef in the area. The composite model approach is especially valuable in interpreting pool size and probable oil recovery for pools in the Zama Field where the complex form of reef is common. In the Rainbow Field the design of improved recovery schemes has been comparatively straightforward and a majority of pools in that field are now subject to some form of enhanced recovery where pressure decline had indicated the need for it.

Annual progress reports for more than 250 enhanced recovery schemes are received by the Board each year. The reports contain, in addition to the basic production, injection and pressure data needed for interpretation of scheme performance, a discussion of significant plant changes and well recompletions made during the year. For example, injection operations conducted in the Medicine River Jurassic C Pool indicated serious pressure drawdowns at wells more than a mile away from the downdip injection wells. As a result the operating company launched a full scale geological and engineering review to develop a three dimensional mathematical model of the reservoir. When developed, the model will be used to re-interpret performance and assist in modifying the injection pattern design to ensure adequate pressure response throughout the scheme area. In the meantime, the scheme was modified by excluding the non-responding

tracts, thus reducing the rate of production from them.

From its own monthly records of production and injection, the Board is also able to maintain a monthly surveillance of any major injection shortages that might occur. During the peak crude oil production demand period in late 1969, it was demonstrated that injection fluid supply was insufficient to meet production withdrawals at about 40 different enhanced recovery projects. The Board will ensure that, during 1970, improved injection fluid supply is developed or schemes otherwise modified to ensure satisfactory operation.

During 1969 the Board approved an application by the Syncrude group of companies to operate a commercial recovery plant in the Fort McMurray area capable of producing 80,000 barrels of product per day. The approval issued by the Board requires that commencement of the recovery of saleable product from the plant shall be not earlier than July 1, 1976, and not later than January 1, 1977. The Syncrude group proposes to continue with pilot and experimental work prior to commencing construction of the plant facilities in 1974.

Experimental recovery activity in oil sands deposits, such as those at Cold Lake, showed a marked downturn in the latter part of 1969. To some extent the abated interest probably occurs as a result of the important oil and gas activities now underway in the Arctic areas of the continent.

The Great Canadian Oil Sands recovery plant located north of Fort McMurray in the Athabasca oil sands deposit produced during 1969 at an average rate of 27,600 barrels per day, continuing to improve its rate of production of synthetic crude oil, although still below the maximum annual rate authorized. The total production of synthetic crude oil during 1969 of just over 10 million barrels was slightly less than 3.5 per cent of the amount of crude oil produced in the Province.

CONSERVATION OF SOLUTION GAS

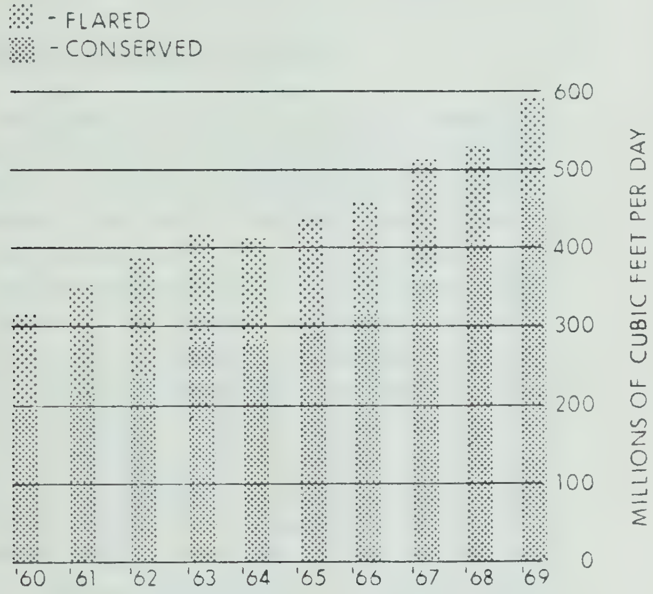
Crude oil as it exists in underground reservoirs is often under moderate to high pressures. In Alberta, these pressures range up to 6,000 pounds per square inch and when oil is brought to the surface and the pressure is reduced to atmospheric conditions, gas dissolved in the oil is released. The volume of this solution gas varies from small amounts to as much as some 3,000 cubic feet per barrel, depending largely on the pressure. In addition to solution gas, the oil in the reservoir may be overlain by a gas cap. If the oil zone thickness is not great it may not be practical to produce the oil without also producing part of this associated gas from the gas cap. The production of the solution gas and in certain instances a portion of the associated gas cap cannot be deferred without also deferring the oil production.

The Board attempts to ensure that as much as is economically possible of the gas produced unavoidably with oil is processed and marketed or injected to an underground formation for pressure maintenance purposes or storage. The Board staff continuously reviews producing oil pools from which the solution gas being produced is not fully conserved. When the volume of gas being flared from any particular pool or group of pools in an area becomes significant, the Board staff makes a study of the economic feasibility of conserving the gas. If it appears gas conservation is feasible, the Board contacts the operators encouraging them to undertake operations for the conservation of the solution gas. This frequently leads to voluntary gas conservation schemes. Where necessary the Board may restrict or prohibit the production of oil should conservation operations be feasible and not be undertaken.

Where the gas produced unavoidably with the oil contains substantial amounts of hydrogen sulphide, the Board is concerned not only

with the conservation of such gas, but also with control of air pollution. In these instances, the Board increases its efforts to bring about gas conservation even though the economics of such conservation may be marginal. In assessing the economics of solution gas conservation where hydrogen sulphide is involved, the Board takes into account the expenditures which would be necessary for pollution control if conservation did not take place.

ALBERTA SOLUTION GAS PRODUCTION



Some 215 billion cubic feet of gas was produced unavoidably with oil in Alberta during 1969. About 78 per cent of this gas production was conserved as compared with some 62 per cent ten years ago in 1960 and some 76 per cent last year. A number of gas conservation projects or expansions thereto are now in the planning or construction stage and the per cent conservation is expected to increase somewhat over the next two years.

Over three-quarters of the solution gas conserved during 1969 was processed for sale as marketable gas, liquid products and sulphur. The remainder was injected into underground reservoirs either for storage or to increase the recovery of crude oil. The marketed solution gas amounted to some 130 billion cubic feet, approximately 10 per cent of the total Provincial marketable gas production.

Efforts towards conservation of solution gas continued during 1969. Gas conservation projects were begun in the Alix, Bantry, Clive, Kaybob South, Olds, Simonette, Sturgeon Lake South, Sundre and Westward Ho Fields and extensions to existing projects, usually associated with extended pool limits, were made in two other fields.

The past year saw a continuance of the trend towards consolidation of oil and gas separation facilities at one point within an oil field. This system, frequently referred to as "fieldgating", makes all the gas available at one point and reduces substantially the facilities needed to gather the solution gas and greatly enhances the economics of gas conservation.

The exceptionally high oil production rates experienced late in 1969 resulted in serious capacity problems for many of the existing gas conservation systems. In addition to this, the oil production rates resulted in excessively high flaring of gas in certain oil fields where conservation is not taking place and where conservation would not be economically feasible unless the high oil rates were to continue indefinitely into the future. In areas where conservation systems did exist, the Board did not permit the flaring of the extra gas resulting from the high oil allowables. In several instances where existing gas processing facilities were unable to handle the additional volumes of gas, the gas was returned to underground formations for temporary storage. Expansion of the processing facilities in several of these areas is expected as soon as a reliable projection of future oil allowables is possible. Following construction of such expanded facilities, the temporarily stored solution gas will be reproduced and processed for the sale of marketable gas, natural gas liquids and sulphur.

POLLUTION CONTROL IN OIL AND GAS FIELDS

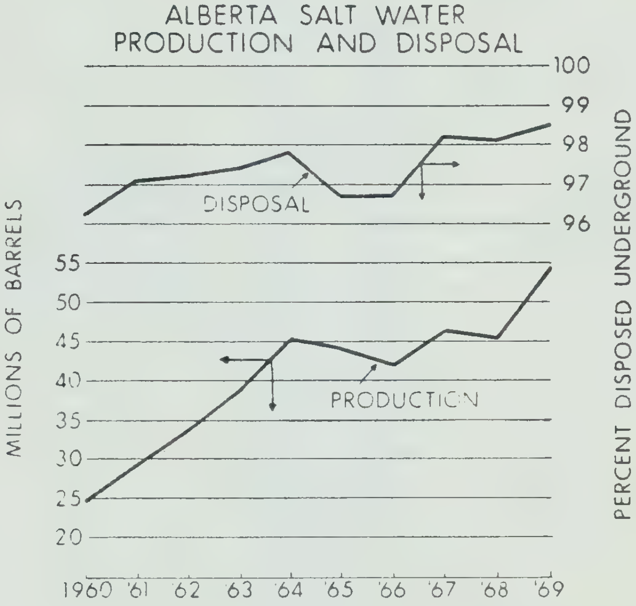
Although the Board's primary responsibility is the conservation of oil and gas, historically it has played a continuing role in the control of the pollution which can result from drilling and producing operations in the oil and gas industry. The Board's pollution control regulations are complementary to the regulations of Government Departments and the Surface Reclamation Council and are designed to minimize pollution of air, soil, surface water or underground water resulting from oil and gas field operations.

SURFACE WATER POLLUTION

If an operator wishes to drill a well near a body of fresh water, he must first obtain approval from the Board of his plans to prevent pollution of the water. The plan must show the location of the well with respect to the stream or lake and must provide for construction and maintenance of dykes, reservoirs, or other installations to contain any spilled fluids that might pollute the water. The method to be used for final disposition of mud, oil, water or other waste associated with the drilling operation must also be shown. The drilling and production operations are inspected frequently by Board and Department of Lands and Forests staff to ensure compliance with these special requirements.

OIL AND SALT WATER DISPOSAL

The Board's regulations prohibit the storage of oil in pits and limit the storage or disposition of any salt water produced with oil or gas. The current regulation allows disposition of up to 600 barrels of salt water per month in an earthen pit. This volume is reduced successively as the number of wells increases in an area or as facilities become available for disposal to an underground formation. Most earthen pits used for disposal of salt water are subject to a limit of 100 barrels a month. Only one pit is allowed at each battery and the size and construction of the pit is specified to ensure that no water seeps through the walls of the pit to contaminate fresh water wells nearby. Disposal of water to salt-water bearing underground formations is enforced as early as possible in the life of each field and the Board encourages the operator to return water to its zone of origin by imposing penalties for water production if the water is not returned to its originating strata. The total volume of salt water produced and the percentage injected to a subsurface formation is shown in the accompanying figure. In 1969, production of salt water increased considerably to a new high of 54,000,000 barrels due to the increased allowables. The total amount returned to underground formations increased slightly to 98.6 per cent of the total produced, as further restrictions were imposed on surface disposal of salt water during the year.



STREAM DISPOSAL PROHIBITED

Another regulation designed to prevent pollution of surface water prohibits the disposition of water, drilling fluids, oil or any products from a well into a lake or stream or any stratum containing potable water. The prohibition against releasing waste water to a stream is a deviation from the common notion that a

stream has a capacity to carry waste material which may be used for disposal of sewage and industrial wastes. Because the Board is familiar with the potential for disposition of waste water to underground zones, it has not allowed the use of fresh water streams as waste disposal sources but has required disposition of waste material to suitable underground formations.

WATER WELL PROTECTION

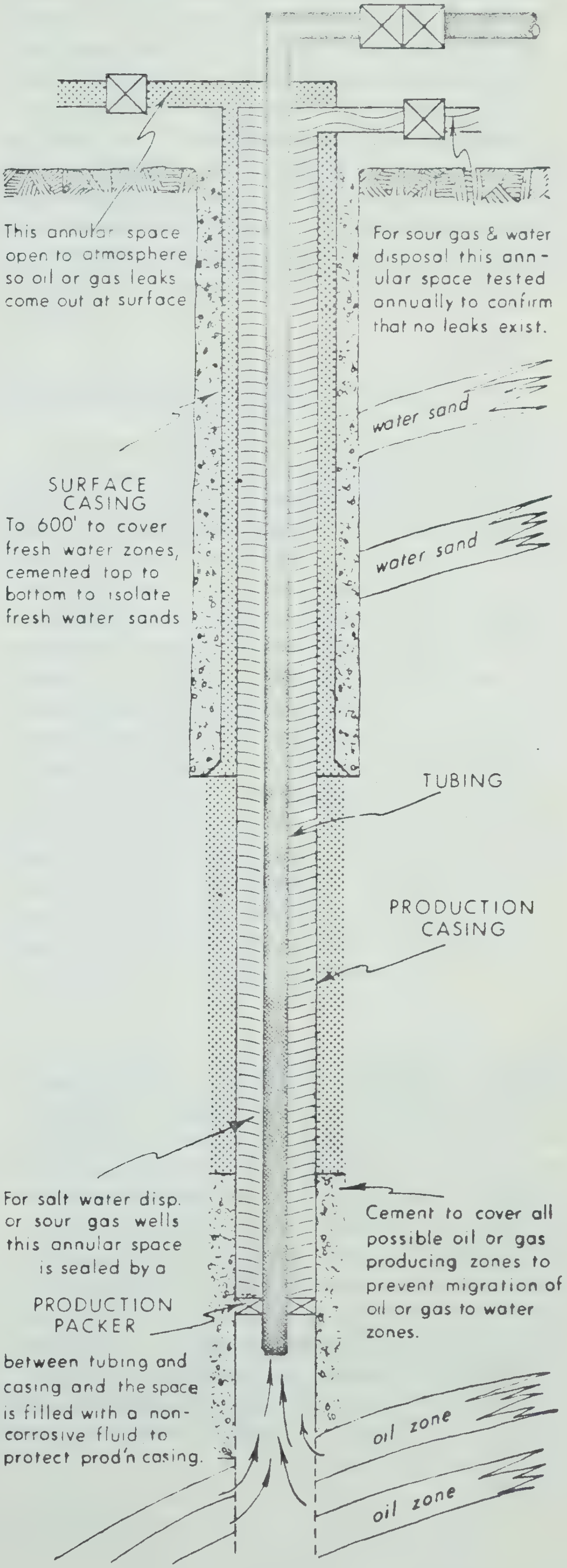
The protection of underground fresh water supplies from contamination by oil, gas or salt water produced from oil or gas wells is another important area in which the Board has a regulatory responsibility. Comprehensive surface casing and cementing requirements are designed to seal fresh water stratum from penetration by drilling mud or produced fluids which might leak into the zones. These casing and cementing requirements also prevent depletion of fresh water stratum which may result from water flowing from one zone to another. The Board's policy currently protects all fresh water zones down to a depth of 600 feet throughout the majority of the Province and down to 900 feet in the south-east corner of the Province where the Milk River zone is an important source of fresh water. In many areas of the Province, water occurring at depths below 600 feet is often brackish and not suitable for human consumption. The average depth of farm water wells today is about 100 feet but there is clear evidence that people are drilling to deeper zones to obtain water for domestic use.

SPECIAL WELL EQUIPMENT

Further protection against invasion of fresh water zones is afforded by regulations which require that the space between the surface casing and the adjacent casing string be open to the atmosphere so that if oil or gas happens to leak out of the production casing, it will be vented at the well head rather than being forced by accumulating pressure into a fresh water zone in the well.

Where salt water is disposed of to a subsurface formation, the regulations require the

WELL EQUIPMENT TO PREVENT POLLUTION



This annular space open to atmosphere so oil or gas leaks come out at surface

For sour gas & water disposal this annular space tested annually to confirm that no leaks exist.

SURFACE CASING
To 600' to cover fresh water zones, cemented top to bottom to isolate fresh water sands

For salt water disp. or sour gas wells this annular space is sealed by a PRODUCTION PACKER between tubing and casing and the space is filled with a non-corrosive fluid to protect prod'n casing.

Cement to cover all possible oil or gas producing zones to prevent migration of oil or gas to water zones.

operator to set a string of tubing inside the production casing and to install a packing element at the bottom of the tubing so as to form a sealed annular space. This space is filled with a non-corrosive liquid to prevent salt water from corroding the tubing or casing which could lead to salt water leaks. A test must be made each year to ensure that the packing element is continuing to isolate the water being injected from the annular space. These special well equipment requirements are illustrated in the adjoining figure.

CEMENTING OF CASING

When a string of production casing is run into an oil or gas zone, the Board specifies the minimum amount of cement that must be pumped around the outside of the casing to ensure that the oil and gas is confined to its own formation. To ensure that the amount of cement used is adequate, the Board requires the operator to run in the well a device which records the diameter of the hole and thus allows him to calculate the amount of cement required. If there is any doubt as to the height to which the cement rose on the outside of the casing, the Board asks that a special log be run inside the casing to determine the height of cement outside. In many shallow holes and for the surface casing string, the owner is required to fill the hole outside the casing with cement from bottom to top.

AIR POLLUTION CONTROL

Air pollution in the oil industry occurs because of the presence of hydrogen sulphide in oil and gas. This chemical can be recognized by its odor of rotten eggs. When gas containing hydrogen sulphide is burned, it is converted to sulphur dioxide, which has the sharp and acrid odor characteristic of burnt sulphur. Both of these pollutants are injurious to health and sulphur dioxide can be particularly harmful to plant growth. Air pollution regulations are designed to prevent the accidental escape of hydrogen sulphide and also to prohibit the release of hydrogen sulphide during ordinary producing operations. The pollution caused by sulphur dioxide, which results when sour gas is burned, is controlled by specifying the use of high flare stacks to disperse the sulphur dioxide. The stacks are designed to ensure that the sulphur dioxide concentration at ground level is below the odor threshold and well below the amount that might injure human, animal or plant life. Standards specifying permissible concentrations of pollutants are set by the Department of Health. The Department and the Board work together to investigate reports of pollution, determine the source and devise methods of control.

ACCIDENTAL RELEASES PREVENTED

To prevent the accidental release of gas containing hydrogen sulphide, the Board's regulations require special equipment at a sour gas well. The well head must be equipped with two master valves installed directly in line with each other so that if one fails, the second one can be closed. A production packer is set between the tubing and production casing to isolate the interior of the production casing from the corrosive action of the sour oil or gas. The working pressure of the well head fittings is specified to ensure that the equipment will not fail under full well pressure. The pressure used in stimulation treatments of the well is restricted to ensure that excess pressure will not rupture the casing or well head fittings. Design, construction and testing of pipe lines is specified and inspected by the Pipe Line Division of the Department of Mines and Minerals.

These, then, are the highlights of the historical role of the Board in pollution control in the oil and gas fields. It appears that, even with periodic inspections, occasional failures in equipment and procedures are bound to occur when one realizes there are thousands of individual wells, tank batteries, processing plants and pipe lines that make up the producing machinery of the industry. Strengthened regulations and improved co-ordination and enforcement of them, coupled with the industry's new awareness of its pollution responsibilities, will minimize such occurrences and lead to swift remedial action.

(From Conservation in Alberta 1969)

ALBERTA'S OIL PRODUCTIVE CAPACITY

The demand for Alberta oil increased dramatically during the last few months of 1969 and the first two months of 1970. The major reason for the increase was the growth in exports to the United States, particularly to the mid-west area. An interesting aspect of this surge in demand related to the strain it placed on Alberta's production facilities and the steps taken by the industry to satisfy the market requirements.

In October 1969 the Board estimated that the Alberta industry was currently capable of delivering slightly more than 900 thousand barrels of oil per day. This capacity was comfortably in excess of the then current market requirements of some 800 thousand barrels per day. This situation changed significantly during November and December and by the end of the year the safety margin between capacity and demand had virtually disappeared.

To appreciate the problem confronting industry at this time one must recognize that during the last part of 1969 it was extremely difficult to predict future growth in market requirements. Exports to the United States were limited by informal arrangements between the Canadian and United States Governments but there was increasing uncertainty as to whether the system would remain in effect. By December demand reached the 907 thousand barrels per day level, and a good deal of evidence suggested a significant relaxation in the restriction of Canadian imports. The Board was advised by crude oil purchasers in late December of large increases in requirements for January and February 1970. The increase of some 100 thousand barrels per day in their nominations from December to January was followed by a further increase of 130 thousand barrels per day in February.

It was obvious to both the industry and the Board that unless immediate action was taken these additional requirements could not be supplied from Alberta reserves. With the prospect of higher allowables each operator examined in detail possible means whereby increased deliveries could be made available to the trans-continental pipe line system. The industry was naturally reluctant to make long term capital investment in new capacity if the surge in demand were to be short lived. Also, due to the short period of time available in which to make modifications to producing facilities the operating companies were quite restricted in their possible scope of action. Nevertheless, and in spite of these restraints, the success of their efforts is attested to by the very substantial growth in capacity that occurred during December and more particularly in January and February. In fact the increases in productive capacity that occurred in each of these months was greater than the average annual increase during the previous decade.

The increased capacity was achieved by a combination of various efforts. In some instances it involved drilling additional wells. In several fields where it is required that gas produced with oil be conserved, the owners devised temporary re-injection facilities for the gas in order to circumvent the bottle necks created by limited gas processing plant facilities. There were several instances where increased pipe line capacity was obtained by increasing the pump capacity. It is difficult to relate the specific increase in capacity to each of these categories since they are frequently overlapping. However, it is possible in many cases to identify the initial capacity improvement. On this basis the 209 thousand barrels per day increase in effective capacity which occurred from October 1969 to February 1970 can be divided as follows:

Well head or field improvements	29%
Plant expansions	13%
Re-injection of related gas	30%
Pipe line expansions	28%

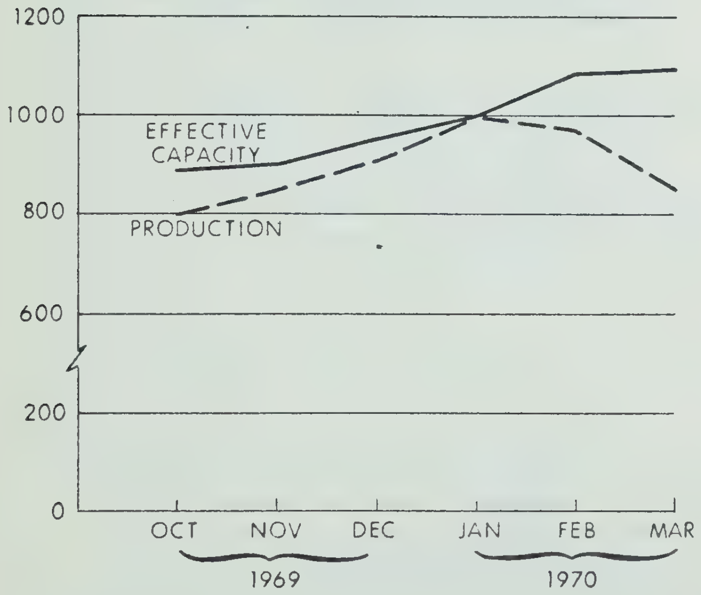
In spite of industry's dramatic response and successful efforts to increase the Provincial productive capacity, events in February 1970 left some of this capacity unused. Virtually all of the increase in the demand of the United

States refiners required delivery through the Interprovincial Pipe Line system. By late January this line reached maximum throughput and available storage facilities were saturated. Consequently in February Alberta producers were forced to reduce their production rates and some of the export demand was not supplied.

The accompanying graph depicts the changes in effective capacity and production that occurred during the period October 1969 to March 1970. The decrease that occurred in production in March was an outcome of the United States Government decision during March to resume restricting imports of Canadian oil. The new import quotas were substantially less than the shipments which occurred during January and February.

EFFECTIVE CAPACITY AND PRODUCTION, Oct. 1969 – Mar. 1970

(Light, medium and heavy conventional oil in thousands of barrels per day)



One might well wonder why the Alberta producing industry would experience difficulty in supplying market requirements when the available reserves are so large in relation to these requirements. To set this matter in perspective reference can be made to the Board's estimate of potential productive capacity called "The Maximum Efficient Reservoir Capacity" (MER), which at the end of 1969 was estimated to be some 2.3 million barrels per day. It must be emphasized, however, that this is potential not actual capacity, and would only be developed given both sufficient market demand and time to install the necessary facilities. A more readily appreciated expression of productive capacity is the volume of oil which completed oil wells could produce at the well head at any point in time. A further difference between this developed well head capacity and the effective crude oil capacity of the Province is created by limitations in both field and processing facilities, in Provincial pipe line capacity, and by daily operations problems.

A summary of the Board's estimates of the various productive capacities as at the end of 1969 is provided below in thousands of barrels per day:

Maximum Efficient Reservoir Capacity	2,300
Developed Well Head Capacity	1,600
Developed Capacity adjusted for Field and Processing Facilities	1,070
Developed Capacity further adjusted for Pipe Line System Limitations	1,000
Effective Productive Capacity	950

The effective productive capacity recognizes that all segments of the Province - wide production system will not be operating at 100 per cent capacity throughout the month. Experience has demonstrated that some allowances must be made for minor repairs, routine maintenance and other day to day problems. The Board allows five per cent of capacity to accommodate this type of situation.

The figure on the following page illustrates the changes that have occurred during the last decade in productive capacities and in production. The MER capacity grew

rapidly from 1 million barrels of oil per day at the end of 1960 to some 2.3 million barrels per day at the end of 1969. The discontinuities that are depicted in the diagram are not significant but relate primarily to different methods of estimating potential capacity. Developed well head capacity increased substantially during the decade also, but it is noteworthy that the growth pattern following 1964 was substantially different than that for the MER. Whereas the MER capacity increased by some 1.3 million barrels per day during the ten year period, the developed well head capacity increased by only about one-third of this amount. It is also interesting to note that effective capacity grew even more slowly with a growth of only one-sixth of the increase in the MER capacity.

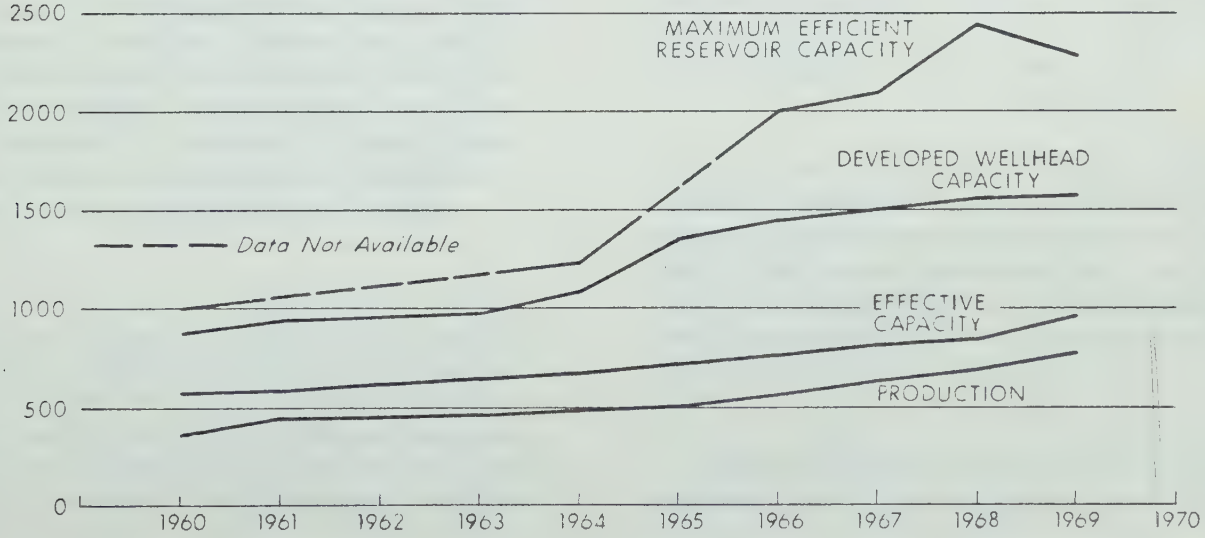
The diversions in the capacities indicated in the figure are attributable to two main factors — the cost to the owner of idle capacity and the method of distributing market demand to wells and pools. Capacity that is idle represents a cost to the producing industry. It is natural that the industry would attempt to reduce this cost by minimizing the extent of excess capacity. Consequently facilities such as processing plants and pipe lines are normally sized to conform to expected market requirements, rather than to the potential capacity of the reservoirs or the actual developed well head capacity.

The relationship between effective capacity, developed well head capacity and maximum efficient reservoir capacity is also influenced by the particular method employed to distribute the market demand to wells and pools in the Province. Following a public hearing that was held in 1963 the Board adopted a new proration plan which came into effect on a partial basis in May 1965. The new plan placed much greater emphasis than heretofore on reserves and placed substantially less emphasis on wells. Under the new plan owners have drilled significantly fewer development wells. As a consequence the developed well head capacity during the last half of the decade ceased to keep pace with growth in the MER and tended more to parallel the growth in crude oil demand.

The figure demonstrates that over the ten-year period there has been more than sufficient effective capacity to meet market requirements. However, during the latter part of the period

ALBERTA PRODUCTIVE CAPACITY AND PRODUCTION, 1960 – 1969

(Light, medium and heavy conventional oil in thousands of barrels per day.)



the gap between capacity and demand narrowed considerably. Average production for 1966 was 70 per cent of year-end effective capacity. By 1969 the amount utilized rose to 80 per cent. Peak month utilization rose even more sharply from 79 per cent of effective capacity in 1966 to 95 per cent in 1969.

Experience gained during the last few months of 1969 and the first three months of 1970 demonstrates that the industry's actual productive capacity at any point in time is strongly influenced by the anticipated market requirements. Large unexpected increases in demand may not be completely satisfied unless there is sufficient time to modify the existing production facilities. Furthermore, should the increase in demand be concentrated in one market area there would be even greater pressure on the available pipe line capacity serving that area and there would be a greater likelihood of the industry not being able to meet all demands. Nevertheless experience has clearly proven that the oil producing industry can respond quickly to special circumstances and that on short notice production levels can be expanded to a surprising and gratifying degree.

SUMMARY OF BOARD OPERATIONS — 1969

ORGANIZATION AND STAFF

The three Board members, G. W. Govier, P. Eng., Chairman, A. F. Manyluk, P. Eng., Deputy Chairman and V. Millard, Board Member, are appointed by the Lieutenant Governor in Council.

The Chief Engineer and the Solicitor act as senior advisers to the Board. They provide technical and legal advice directly to the Board and, when appointed for the purpose, they function as Acting Board Members. The Chief Engineer also chairs an Applications Advisory Group which includes the Board Solicitor and the Managers of the Gas, Oil and Development Departments. This Group advises the Board on routine applications. In addition, the Managers of the engineering departments and other senior staff serve as examiners at public hearings. A list of all Department Managers is provided on the back page of this report.

The Board has a total staff of 275, of which approximately 50 are Engineers or Geologists. About 200 staff members are located in the Calgary head office, with the balance assigned to the Core Storage Center in Calgary, the Chemical Laboratory in Edmonton, and the area offices in Edmonton, Red Deer, Drayton Valley, Medicine Hat and Black Diamond.

The Gas Department is primarily concerned with conservation of gas and related products, including propane, butanes, pentanes plus and sulphur. The Department also determines reserves and deliverability of gas, natural gas liquids and sulphur.

The Oil Department is responsible for ensuring conservation and correlative rights in crude oil production operations. It is also responsible for assessment and surveillance of enhanced recovery schemes, assessment of oil reserves, oil well spacing and technical matters relating to the proration plan.

The Development Department, with its Drilling and Production and its Field Divisions, is responsible for the standards and the inspection of procedures, technology and equipment used in drilling and producing wells. Engineers and Technicians in area offices inspect and report on operations in the field.

The Geology Department provides geological interpretations of oil and gas reservoirs. The

Core Storage Center catalogues and retains samples of drill cuttings and cores and provides facilities for their examination by industry and the general public.

The Data Processing Department is responsible for computer programming and systems design. An IBM/360-30 computer, supplemented when necessary by off-premises computer facilities, provides a fully integrated, organization wide data storage, retrieval and processing system.

The Accounting, Economics, Office Services and Personnel Departments complete the Board's organizational structure. They provide information and service to the oil and gas industry, and to the Board and its staff.

IMPORTANT ACTIVITIES IN 1969

General activity during 1969 remained at about the same level as the previous year. Drilling increased along the foothills belt, particularly in the Strachan - Ricinus area, where Cardium oil and Leduc gas fields were developed. In the Alderson area of south-eastern Alberta, approximately 50 gas wells were completed in the shallow and low pressure Milk River formation. The use of air drilling to avoid reservoir damage from drilling fluids has enabled operators to complete Milk River wells as successful gas wells for the first time.

Improvement of pollution control continued to occupy a significant portion of the efforts of the Board's field staff. A survey of methods of handling sour oil was conducted at all batteries in the Province. As a result of the study, the height of flare stacks required at these batteries was increased to provide better dispersion of sulphur dioxide produced by burning the sour gas released from the oil. Gathering and processing of the sour gas was initiated in the Clive and Erskine areas to reduce emissions of sulphur dioxide.

Special regulations were written to protect water fowl in the Zama Hay Lakes area. These shallow lakes and others nearby are the staging grounds for a large number of ducks and geese on their migrations to and from Northern Canada. The regulations pertain to wells and batteries in an area of some 300 square miles and require special completion methods and equipment for the wells and batteries. In addition, drilling and producing operations are closed down completely for periods in the spring and fall to reduce harassment of the birds during their stay on the lakes.

Uses of the Board's computer facilities were expanded, and new systems were designed to prepare and print much of the Board's annual reserves report, to perform reserve calculations, to evaluate pressure build-up in oil and gas wells, and to maintain current drilling data and prepare drilling reports. A procedure was also developed for forecasting proration factors as market demand changes. By year-end a terminal for sharing a large scale, off-premise, computer was being used extensively by the staff. Usage of the Board's IBM/360-30 computer continues at about two shifts per day. A major effort was made to increase data exchange with companies on punchcard or tape so that data processing could be carried on without intermediate posting from paper records.

The Board heard an application by the Canadian Petroleum Association for the Board to modify its policies in determining the volume of gas reserves surplus to the needs of the Province. As a result of the hearing, the Board made changes in its procedures for estimating the amount of gas considered to be available for use by residents of the Province or for export out of the Province. Four applications were considered for the removal of additional gas from the Province. Three of these were approved, resulting in additional export volumes of 5.4 trillion cubic feet. The fourth application was being considered at year-end. Also, an application from Dome Petroleum Limited to allow the removal of an additional 40 million barrels of propane from the Province over a 25 year period was granted.

The Kaybob South-Beaverhill Lake A Pool was further developed during the year with commencement of a scheme to improve the recovery of natural gas liquids. Some 615,000,000 cubic feet of gas will be produced from the reservoir to yield 68,000 barrels per day of natural gas liquids and some 3,700 long tons per day of sulphur. Most of the residue gas will be re-injected into the reservoir to maintain pressure and improve liquid recovery, and about 75,000,000 cubic feet per day will be marketed.

Gas conservation was initiated in 10 new fields and existing conservation schemes were extended in two other fields. Fourteen new gas processing plants were built during the year and additions to five other plants were approved. A processing plant to recover natural gas liquids from gas carried by Alberta Gas Trunk Line was approved for construction at Empress.

The new proration plan announced in 1964 reached full implementation in May 1969. Since that date and with minor exceptions, the market demand for light and medium crude oil has been allocated entirely on the basis of the reserves attributed to a well or pool. Net addition to the Provincial crude oil reserves was the least for some years at 63,000,000 barrels. Significant reserve additions to individual pools included 111,000,000 barrels at Nipisi and 25,000,000 barrels at Carson Creek North, mostly attributable to water injection operations.

The Rainbow-Zama area accounted for 120 new pools and about 30 per cent of the 440 oil wells completed in the Province during the year.

Following initial studies by the staff, the Board urged the operators in about 20 pools to submit enhanced recovery studies for these pools. In about two-thirds of the pools, water flood schemes are being initiated, which will result in a total gain of some 52 million barrels of oil.

The Board considered and approved an application by Texaco Exploration Company for a solvent flood scheme to increase recovery from the important Wizard Lake D-3 A Pool by some 70 million barrels. The injection of some 27 million barrels of solvent to the pool commenced in late 1969. Recoverable crude oil reserves with solvent flooding are expected to be over 320 million barrels.

A great deal of time has been devoted to the understanding of the oil pools in the Rainbow-Zama area, since the pool shape tends to be quite complex and pressure declines have been very marked. Investigation of nearly 300 pools indicated that the producing mechanism is somewhat different than initially supposed. A substantial effort by the industry and the Board was made, and continues, to properly define the rock and fluid characteristics of this very large number of small pools so that improved recovery schemes — on a co-ordinated basis where necessary — may be economically achieved.

REVENUES AND EXPENDITURES

The net expenditure of the Board increased to $2,665,000 in 1969 representing a 7.2 per cent increase over the previous year as compared to an average annual rate of 8.8 per cent during the past five years. Although the entire increase is attributed to salary costs, the rate of increase was well below the five year average of 9.4 per cent.

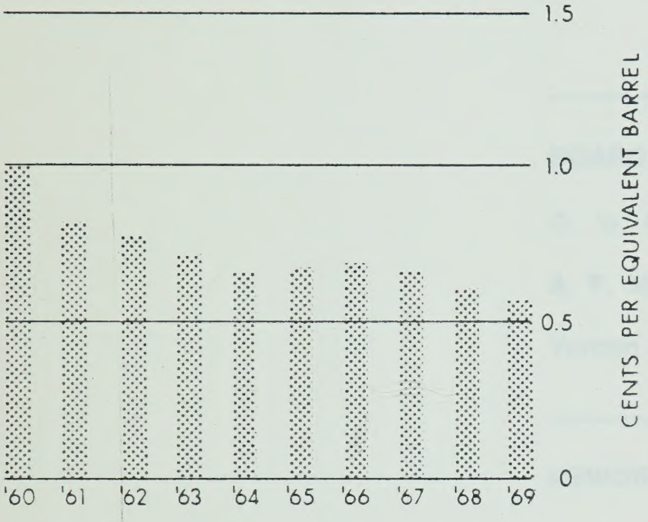
In 1969, 40 per cent of the revenues to meet these expenditures were obtained from the Government of the Province of Alberta and the levy of a tax on oil and gas properties in the Province provided the remainder. Since the Government is taxed as the owner of Crown lands, the Board's operating costs are borne about equally by industry and Government.

During 1969 The Oil and Gas Conservation Act was revised so that from 1970 the Government will provide monies to meet 50 per cent of Board net expenditure and the tax levy will

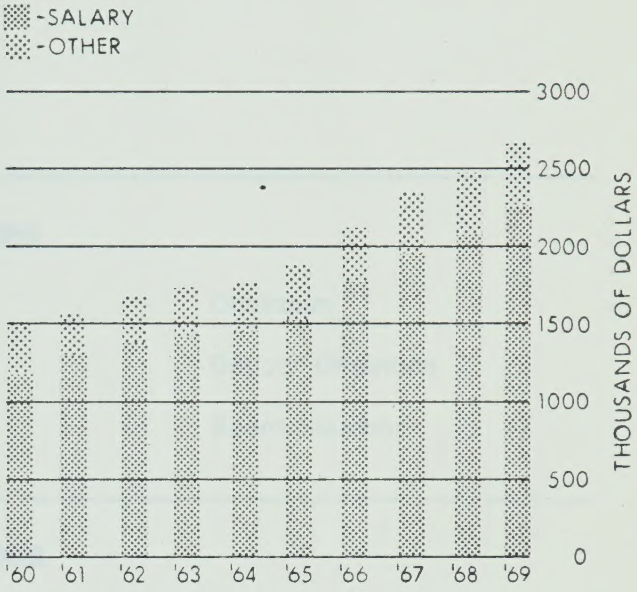
no longer be made on Crown lands. Industry will continue to be taxed for the other 50 per cent.

The accompanying graphs show: (1) the level of Board net expenditures over the past ten years and the relationship of salary expenditure to the total expenditure after the deduction of miscellaneous revenue, and (2) the relationship of Board operations cost to industry production revenues in the Province. The latter is done by reducing Board net expenditure to the number of cents per equivalent barrel of crude oil production. During the last ten years this cost has been reduced from one cent to its present six-tenths of a cent.

BOARD NET EXPENDITURE PER EQUIVALENT BARREL OF CRUDE OIL PRODUCTION



BOARD NET EXPENDITURES



BOARD MEMBERS

G. W. Govier	Chairman
A. F. Manyluk	Deputy Chairman
Vernon Millard	Board Member

SENIOR ADVISORS

D. R. Craig	Chief Engineer
N. A. Macleod	Solicitor

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G. J. DeSorcy	Gas
N. A. Strom	Oil
E. J. Morin	Data Processing
J. R. Pow	Geology
K. W. Fuller	Accounting
J. Rimell	Economics
R. F. Braun	Personnel
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